US011956678B2

(12) United States Patent
McCann et al.

(10) Patent No.: US 11,956,678 B2
(45) Date of Patent: *Apr. 9, 2024

(54) **NEGOTIATION OF QUALITY OF SERVICE (QOS) INFORMATION FOR NETWORK MANAGEMENT TRAFFIC IN A WIRELESS LOCAL AREA NETWORK (WLAN)**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **17/843,656**

(22) Filed: **Jun. 17, 2022**

(65) **Prior Publication Data**

US 2022/0322153 A1 Oct. 6, 2022

Related U.S. Application Data

(63) Continuation of application No. 17/146,189, filed on Jan. 11, 2021, now Pat. No. 11,368,880, which is a (Continued)

(30) **Foreign Application Priority Data**

Mar. 15, 2010 (CA) 2696037

(51) **Int. Cl.**

H04W 28/24	(2009.01)
H04W 74/00	(2009.01)
H04W 84/12	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 28/24*** (2013.01); ***H04W 74/006*** (2013.01); *H04W 84/12* (2013.01)

(58) **Field of Classification Search**

CPC ... H04W 28/24; H04W 74/006; H04W 84/12; H04W 72/12

See application file for complete search history.

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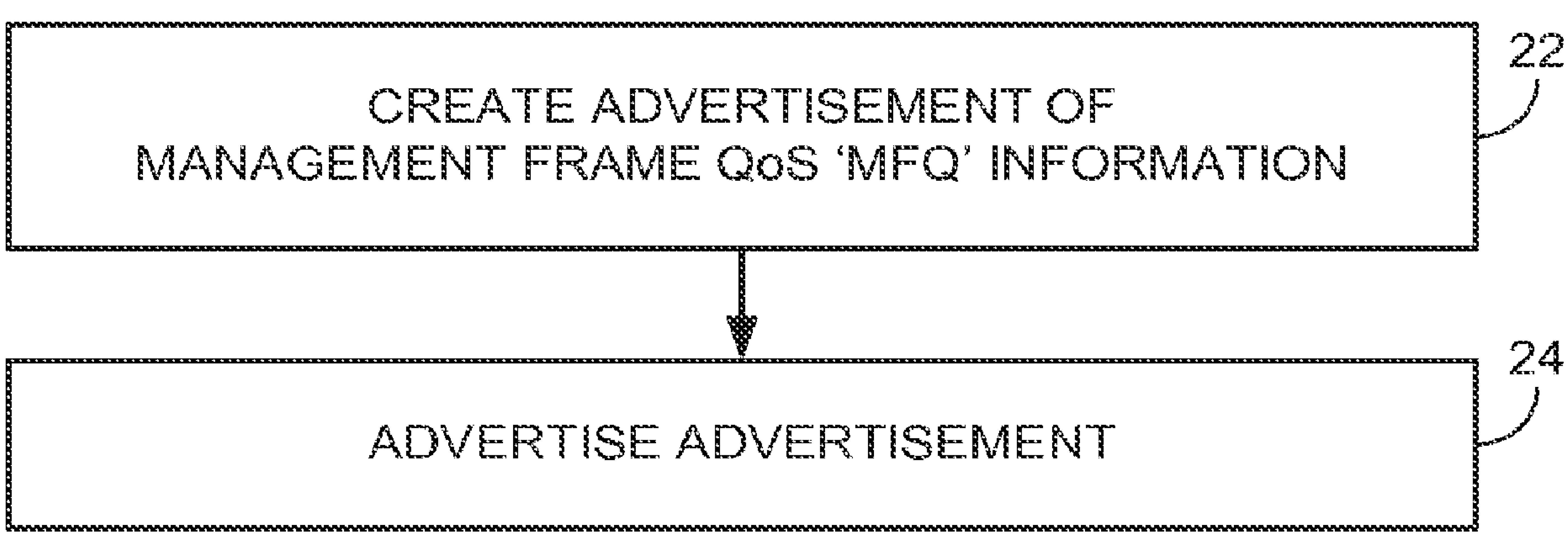
(57) **ABSTRACT**

An access point advertises a management frame quality of service (MFQ) policy that defines an access category used for transmitting a first type of management frame. Each mobile station associated with the access point is to prioritize transmission of management frames according to the MFQ policy advertised by the access point, unless a policy configuration request for the mobile station to prioritize transmission of management frames according to a different MFQ policy has been accepted.

20 Claims, 10 Drawing Sheets



Related U.S. Application Data

continuation of application No. 16/428,350, filed on May 31, 2019, now Pat. No. 10,893,442, which is a continuation of application No. 15/460,991, filed on Mar. 16, 2017, now Pat. No. 10,356,662, which is a continuation of application No. 13/045,658, filed on Mar. 11, 2011, now Pat. No. 9,615,383.

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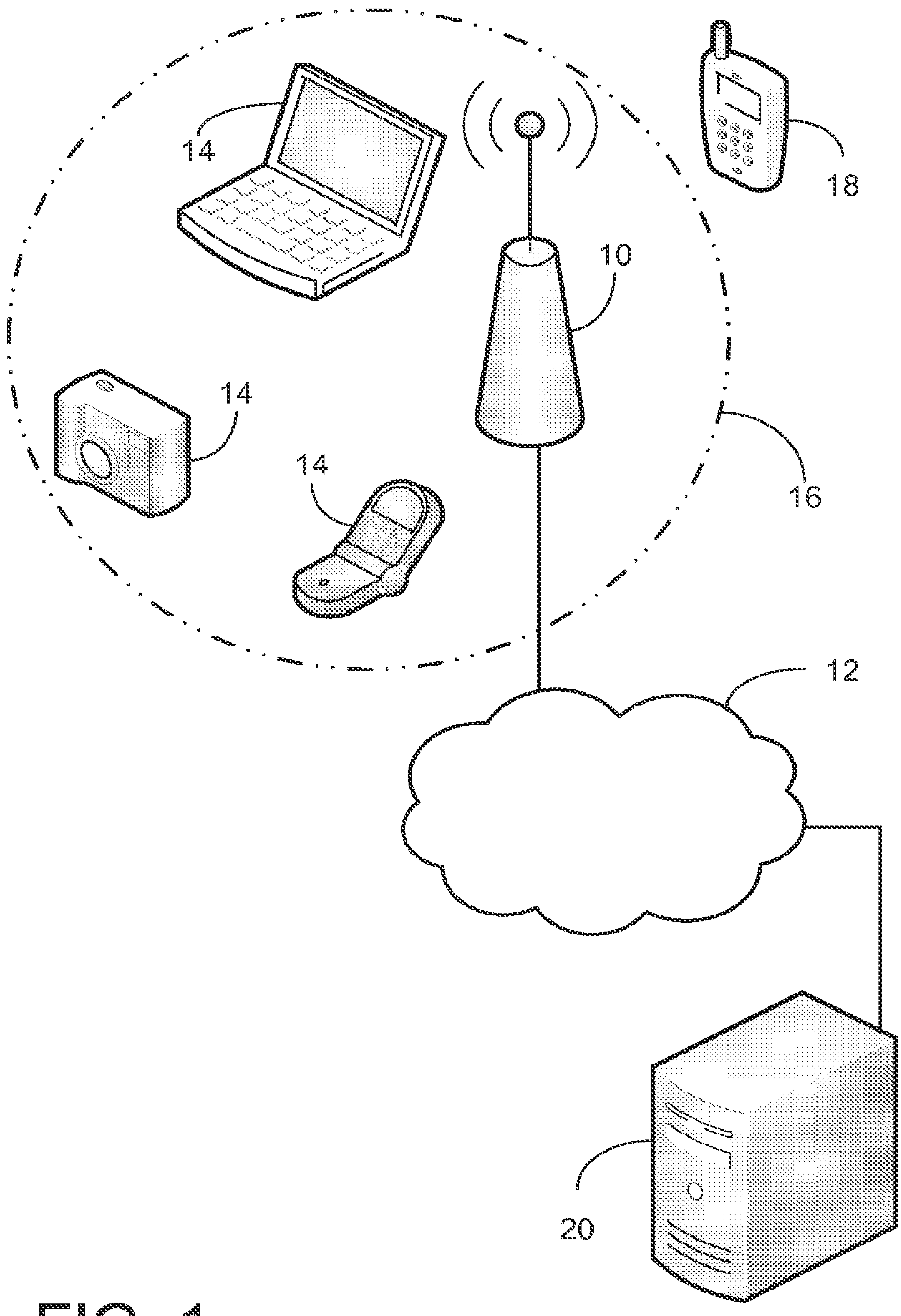


FIG. 1

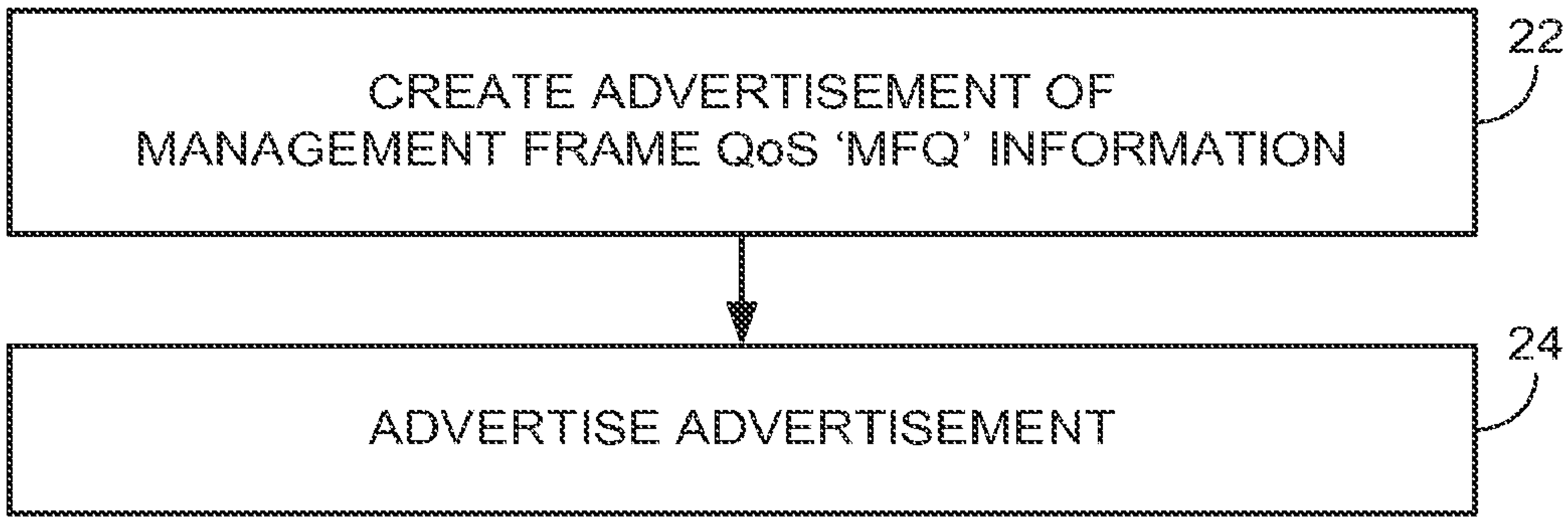


FIG. 2

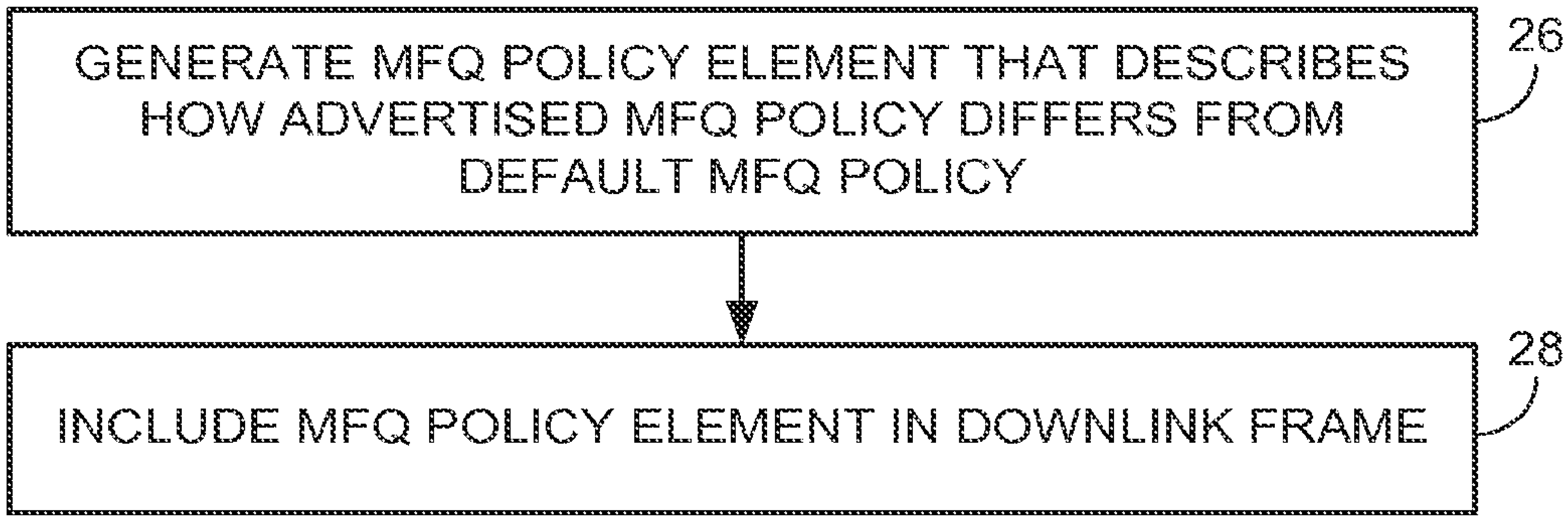


FIG. 3

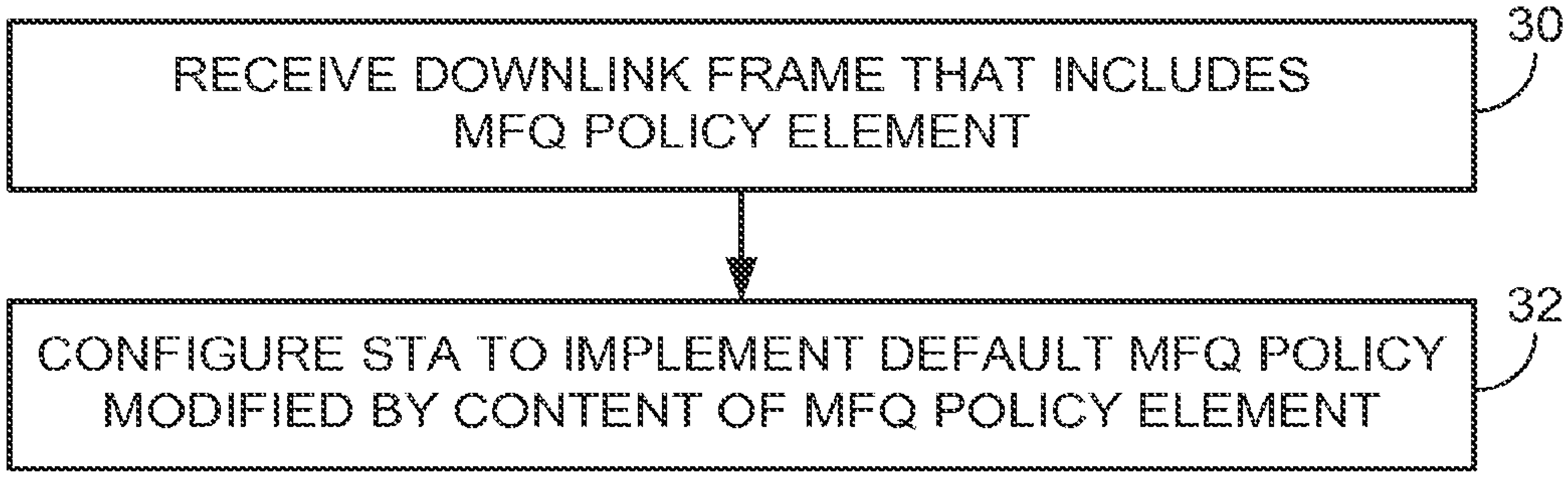
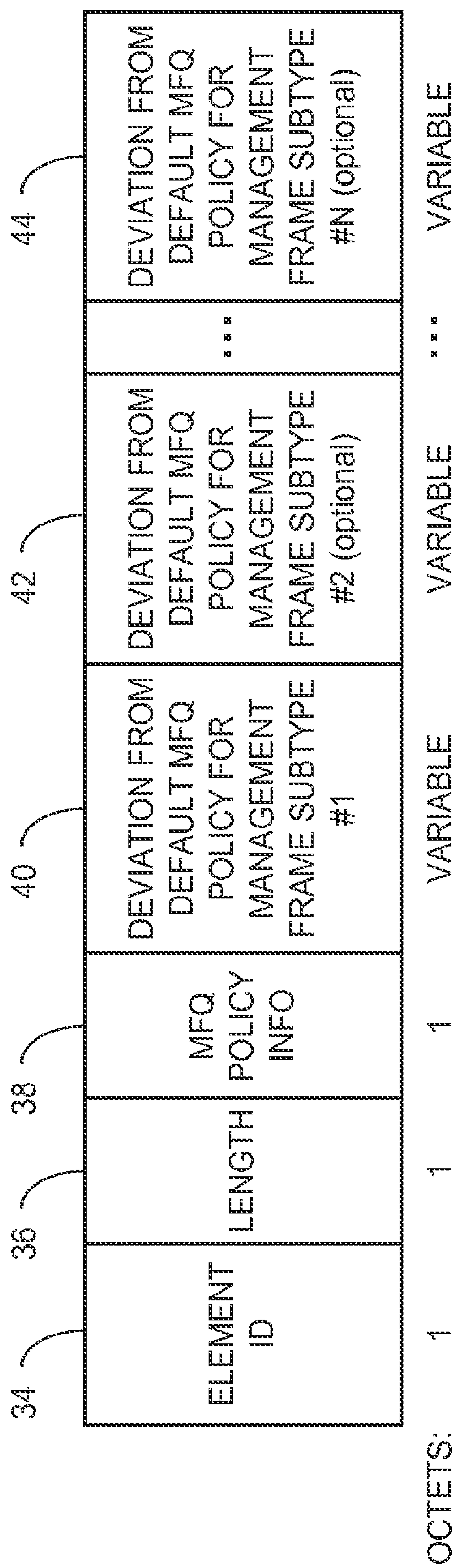


FIG. 4



34
36
38
40
42
44
ELEMENT ID
LENGTH
MFQ POLICY INFO
DEVIATION FROM DEFAULT MFQ POLICY FOR MANAGEMENT FRAME SUBTYPE #1
DEVIATION FROM DEFAULT MFQ POLICY FOR MANAGEMENT FRAME SUBTYPE #2 (optional)
...
DEVIATION FROM DEFAULT MFQ POLICY FOR MANAGEMENT FRAME SUBTYPE #N (optional)
OCTETS:
1
1
1
VARIABLE
VARIABLE
...
VARIABLE

FIG. 5

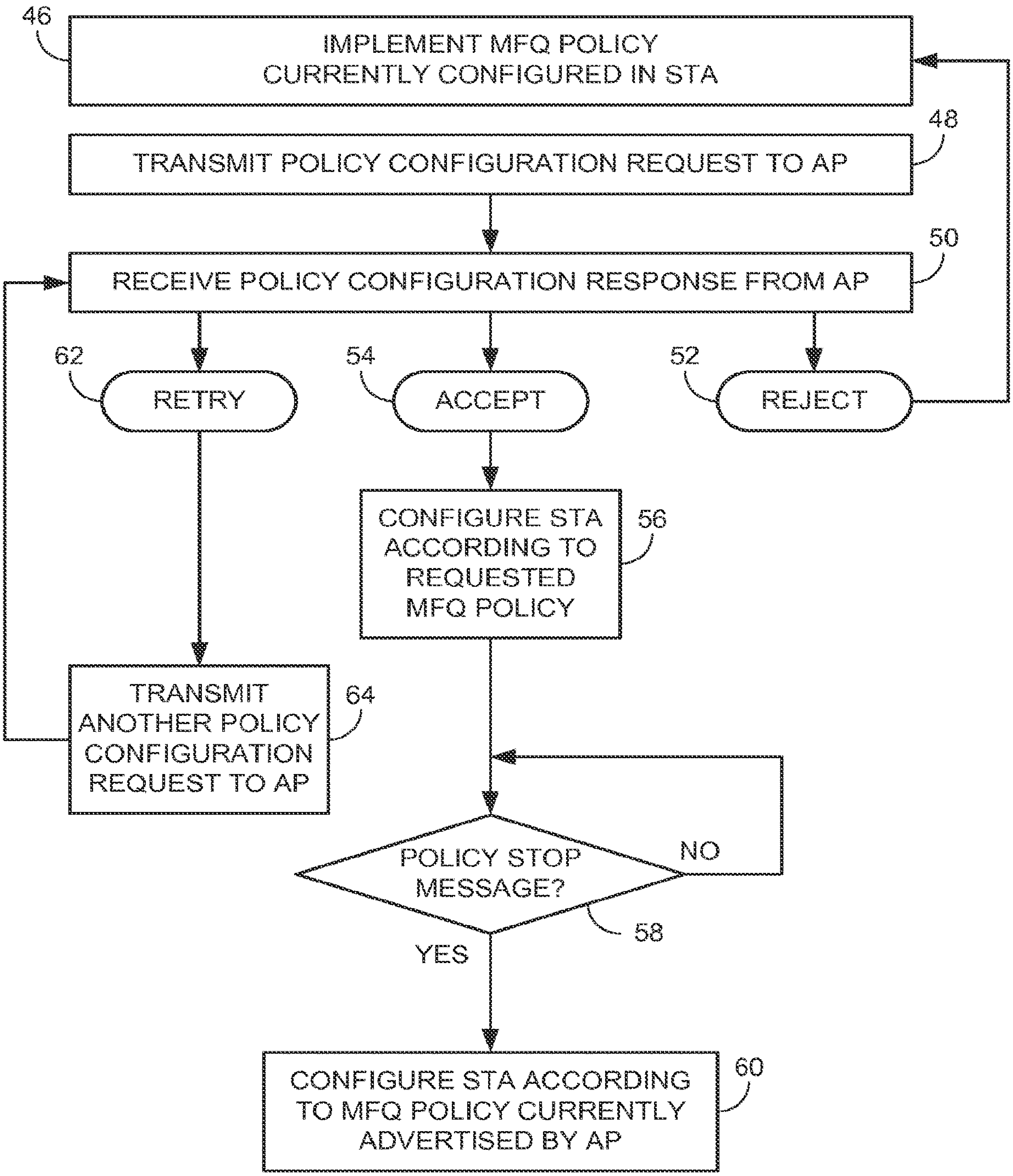

46
IMPLEMENT MFQ POLICY CURRENTLY CONFIGURED IN STA
48
TRANSMIT POLICY CONFIGURATION REQUEST TO AP
50
RECEIVE POLICY CONFIGURATION RESPONSE FROM AP
62
RETRY
54
ACCEPT
52
REJECT
CONFIGURE STA ACCORDING TO REQUESTED MFQ POLICY
56
TRANSMIT ANOTHER POLICY CONFIGURATION REQUEST TO AP
64
POLICY STOP MESSAGE?
NO
58
YES
CONFIGURE STA ACCORDING TO MFQ POLICY CURRENTLY ADVERTISED BY AP
60

FIG. 6

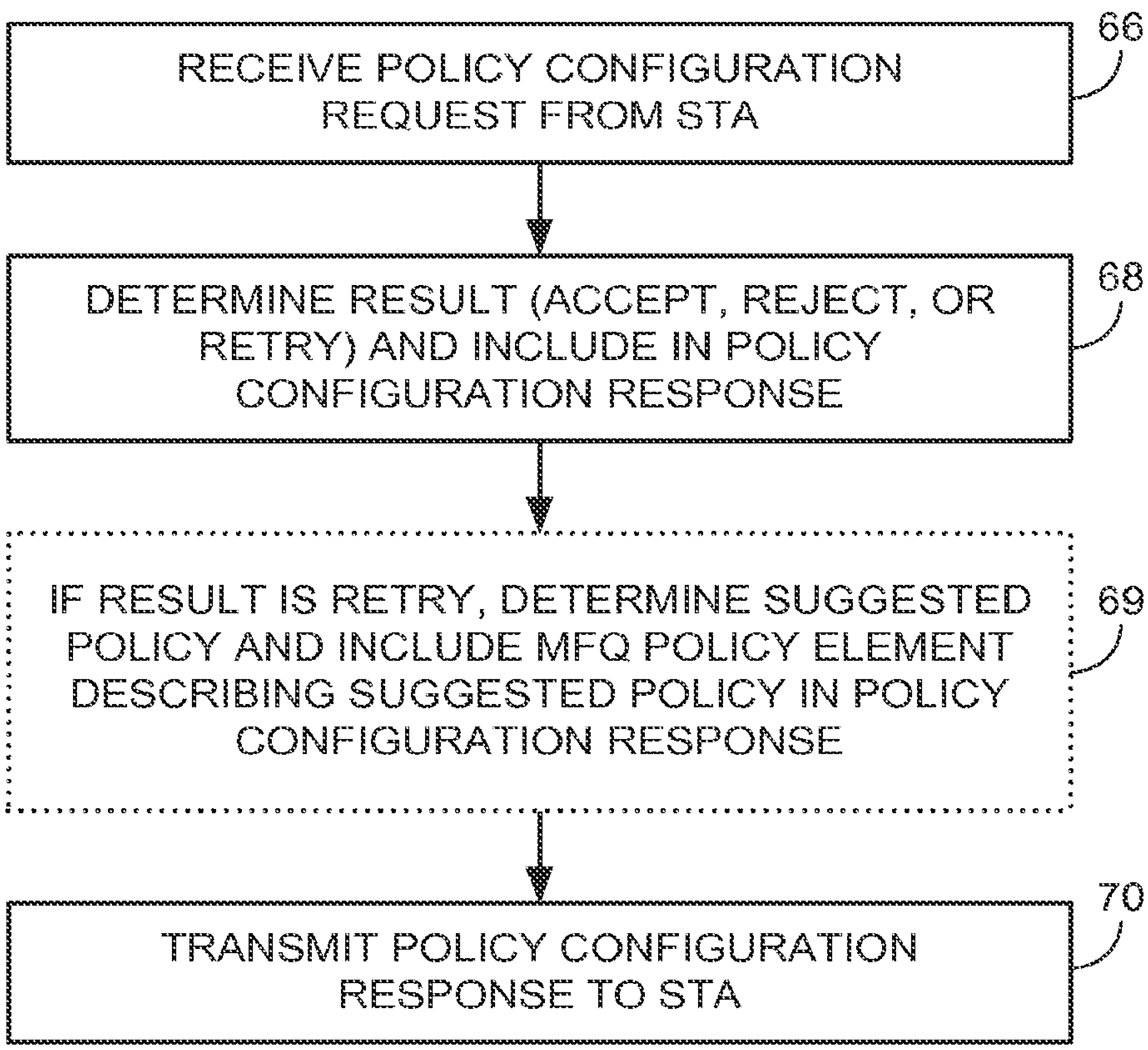

RECEIVE POLICY CONFIGURATION REQUEST FROM STA
66
DETERMINE RESULT (ACCEPT, REJECT, OR RETRY) AND INCLUDE IN POLICY CONFIGURATION RESPONSE
68
IF RESULT IS RETRY, DETERMINE SUGGESTED POLICY AND INCLUDE MFQ POLICY ELEMENT DESCRIBING SUGGESTED POLICY IN POLICY CONFIGURATION RESPONSE
69
TRANSMIT POLICY CONFIGURATION RESPONSE TO STA
70

FIG. 7

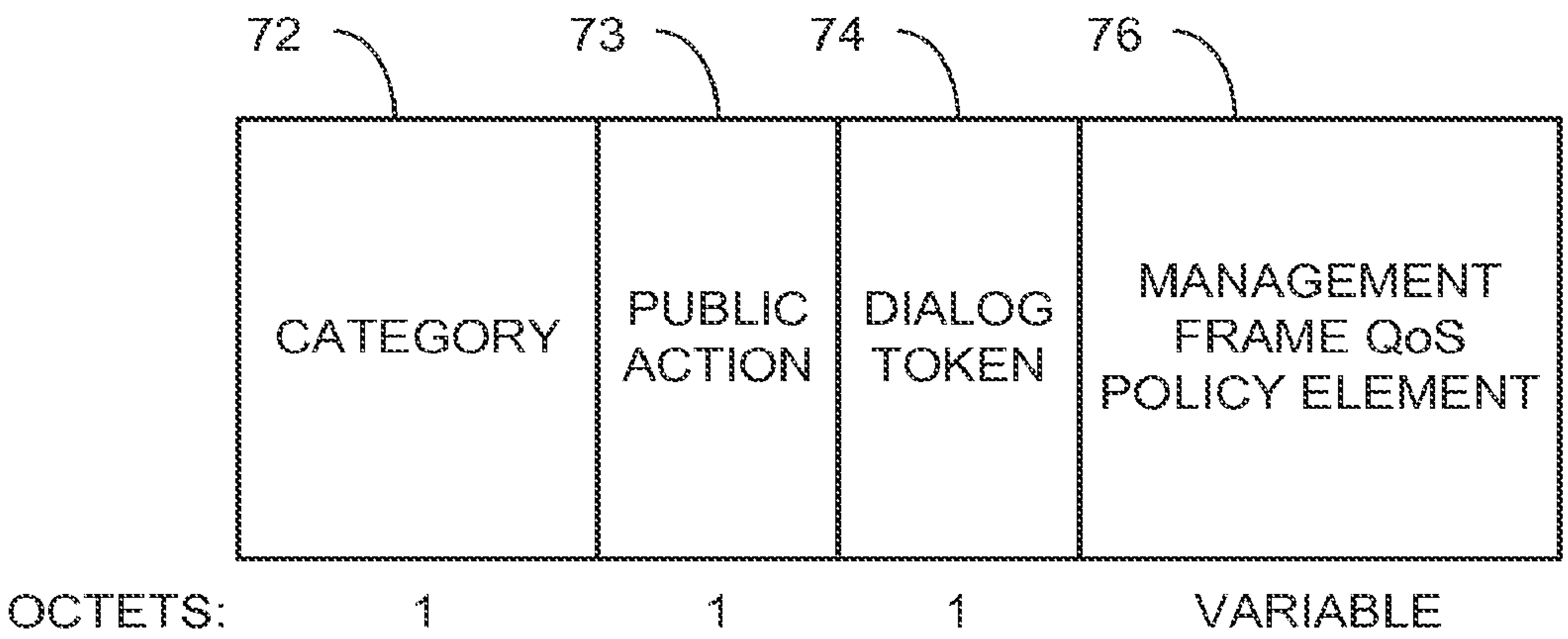


FIG. 8

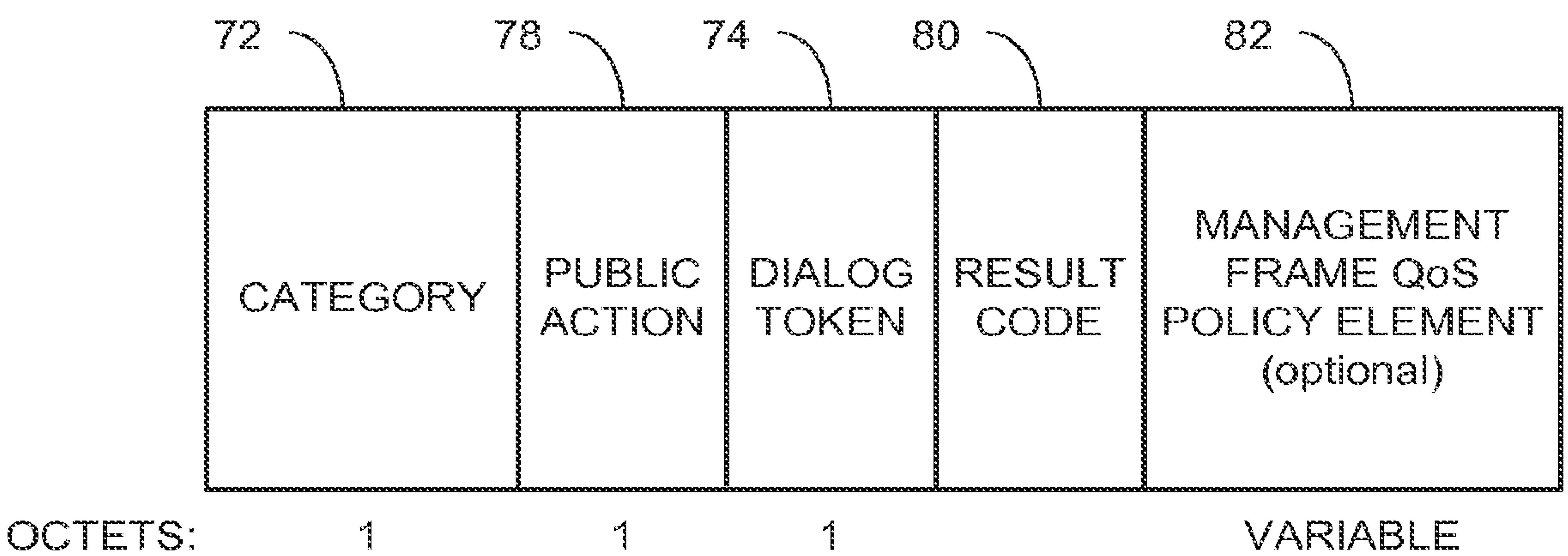


FIG. 9

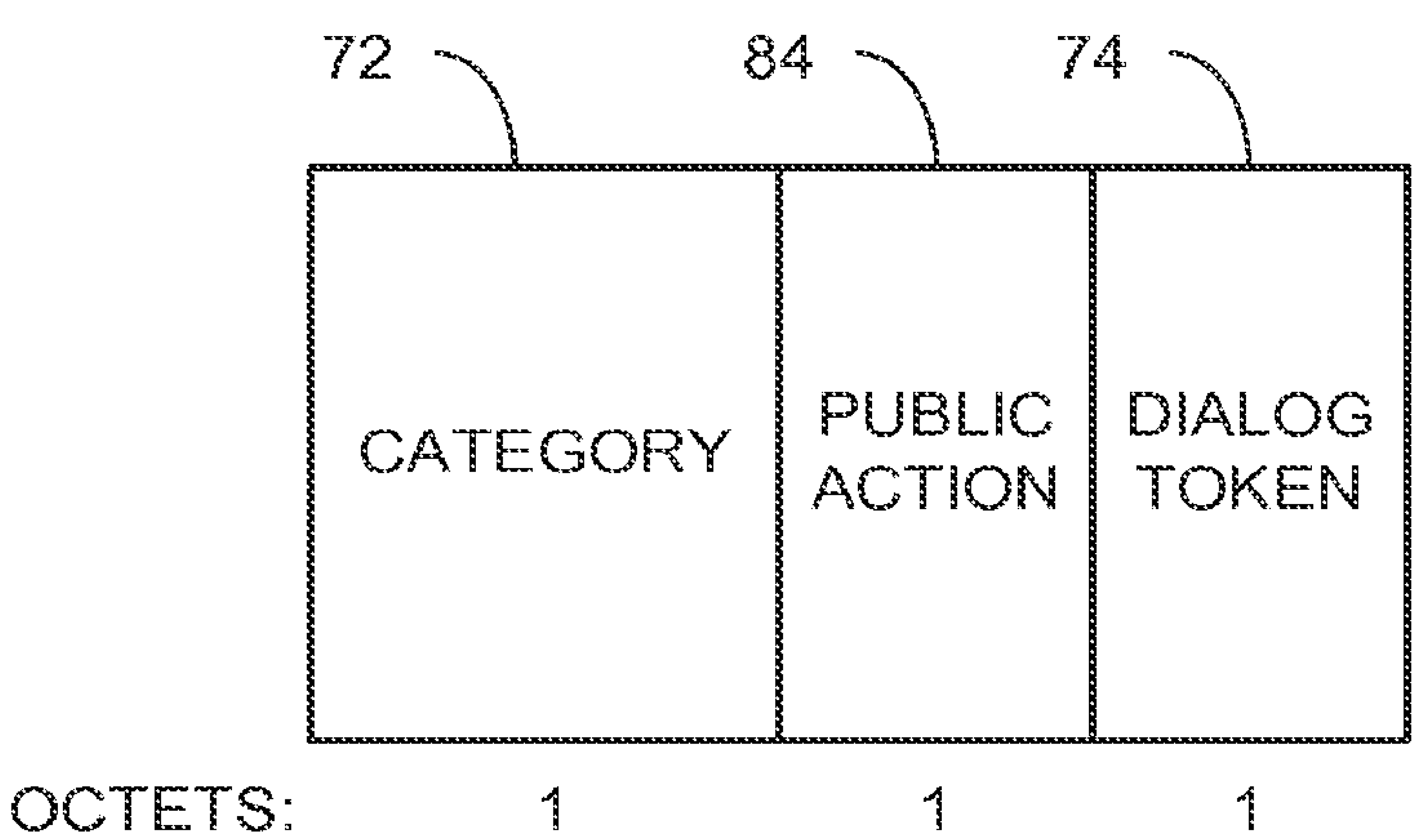


FIG. 10

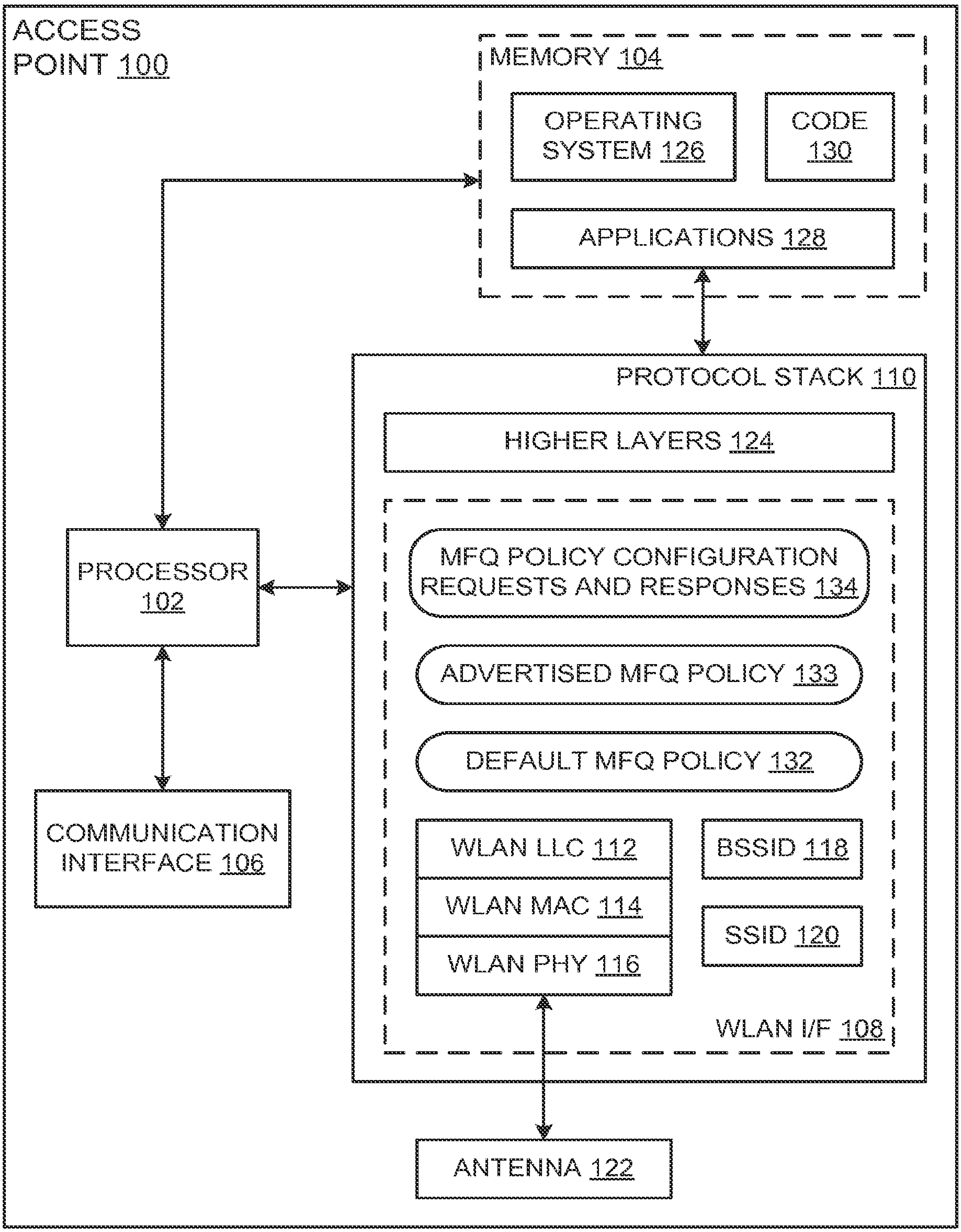

ACCESS
POINT 100
MEMORY 104
OPERATING SYSTEM 126
CODE 130
APPLICATIONS 128
PROTOCOL STACK 110
HIGHER LAYERS 124
PROCESSOR 102
MFQ POLICY CONFIGURATION REQUESTS AND RESPONSES 134
ADVERTISED MFQ POLICY 133
DEFAULT MFQ POLICY 132
COMMUNICATION INTERFACE 106
WLAN LLC 112
WLAN MAC 114
WLAN PHY 116
BSSID 118
SSID 120
WLAN I/F 108
ANTENNA 122

FIG. 11

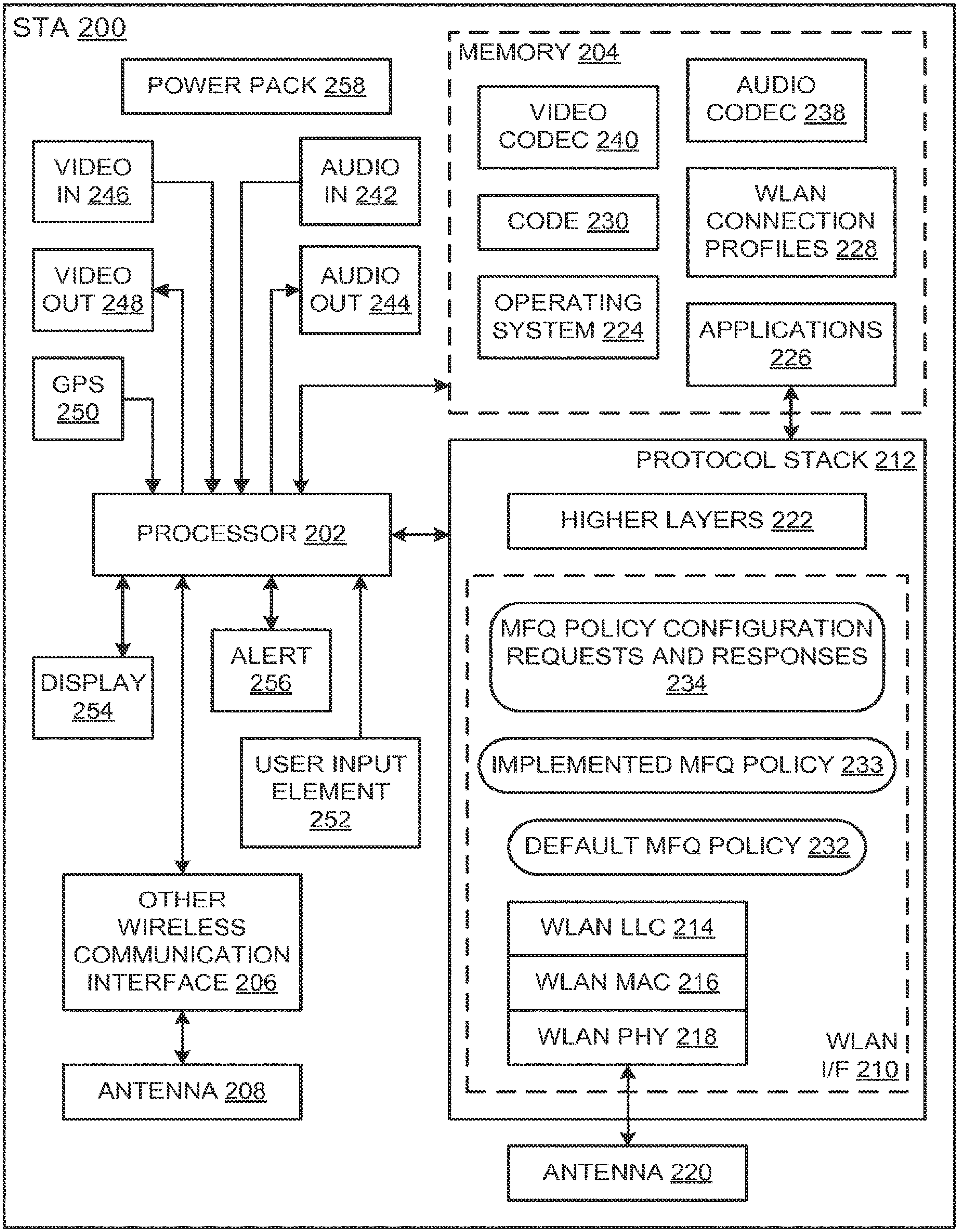

STA 200
POWER PACK 258
MEMORY 204
VIDEO CODEC 240
AUDIO CODEC 238
CODE 230
WLAN CONNECTION PROFILES 228
OPERATING SYSTEM 224
APPLICATIONS 226
VIDEO IN 246
AUDIO IN 242
VIDEO OUT 248
AUDIO OUT 244
GPS 250
PROTOCOL STACK 212
PROCESSOR 202
HIGHER LAYERS 222
MFQ POLICY CONFIGURATION REQUESTS AND RESPONSES 234
DISPLAY 254
ALERT 256
IMPLEMENTED MFQ POLICY 233
USER INPUT ELEMENT 252
DEFAULT MFQ POLICY 232
OTHER WIRELESS COMMUNICATION INTERFACE 206
WLAN LLC 214
WLAN MAC 216
WLAN PHY 218
WLAN I/F 210
ANTENNA 208
ANTENNA 220

FIG. 12

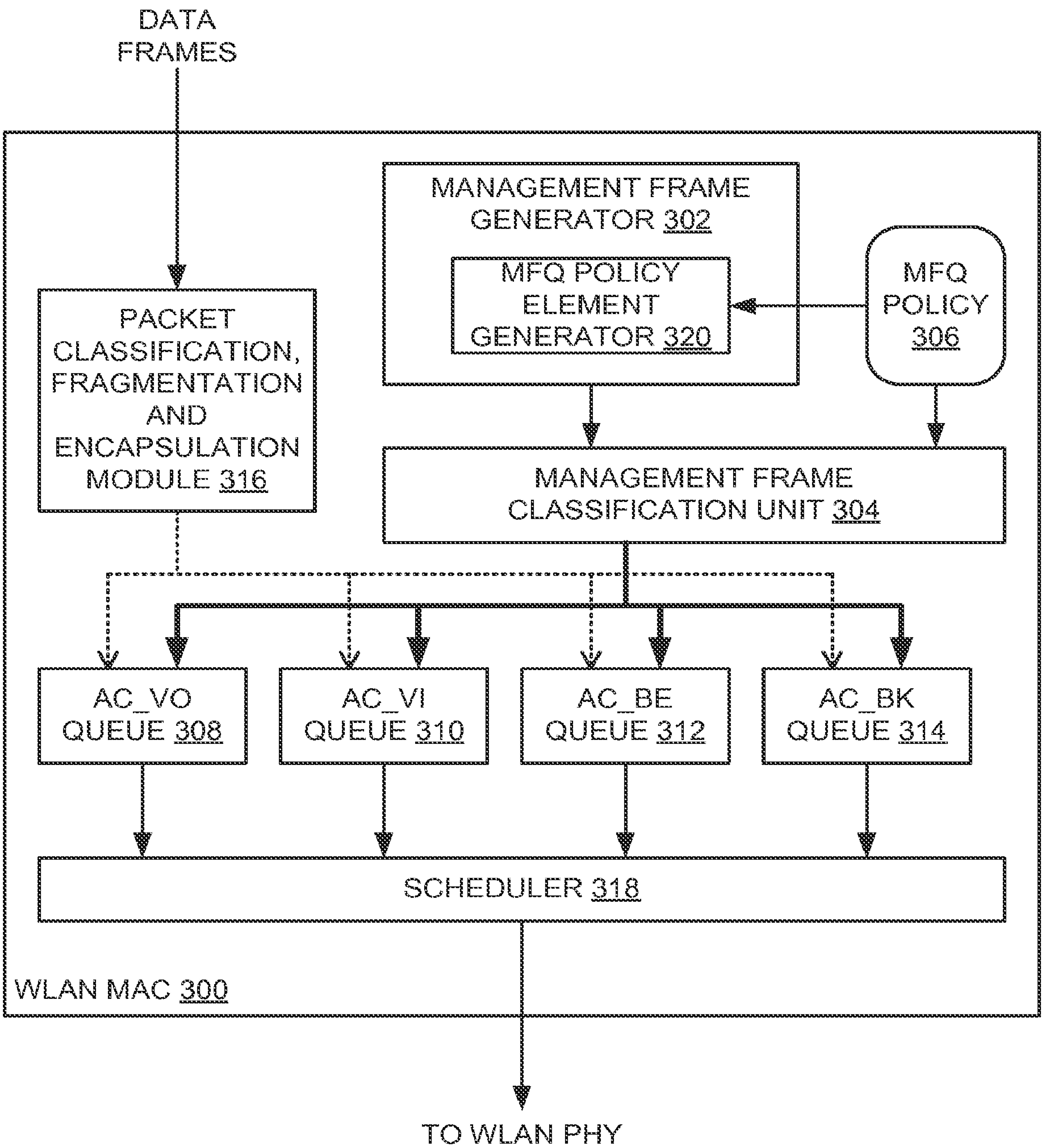

DATA
FRAMES
MANAGEMENT FRAME
GENERATOR 302
MFQ POLICY
ELEMENT
GENERATOR 320
MFQ
POLICY
306
PACKET
CLASSIFICATION,
FRAGMENTATION
AND
ENCAPSULATION
MODULE 316
MANAGEMENT FRAME
CLASSIFICATION UNIT 304
AC_VO
QUEUE 308
AC_VI
QUEUE 310
AC_BE
QUEUE 312
AC_BK
QUEUE 314
SCHEDULER 318
WLAN MAC 300
TO WLAN PHY

FIG. 13

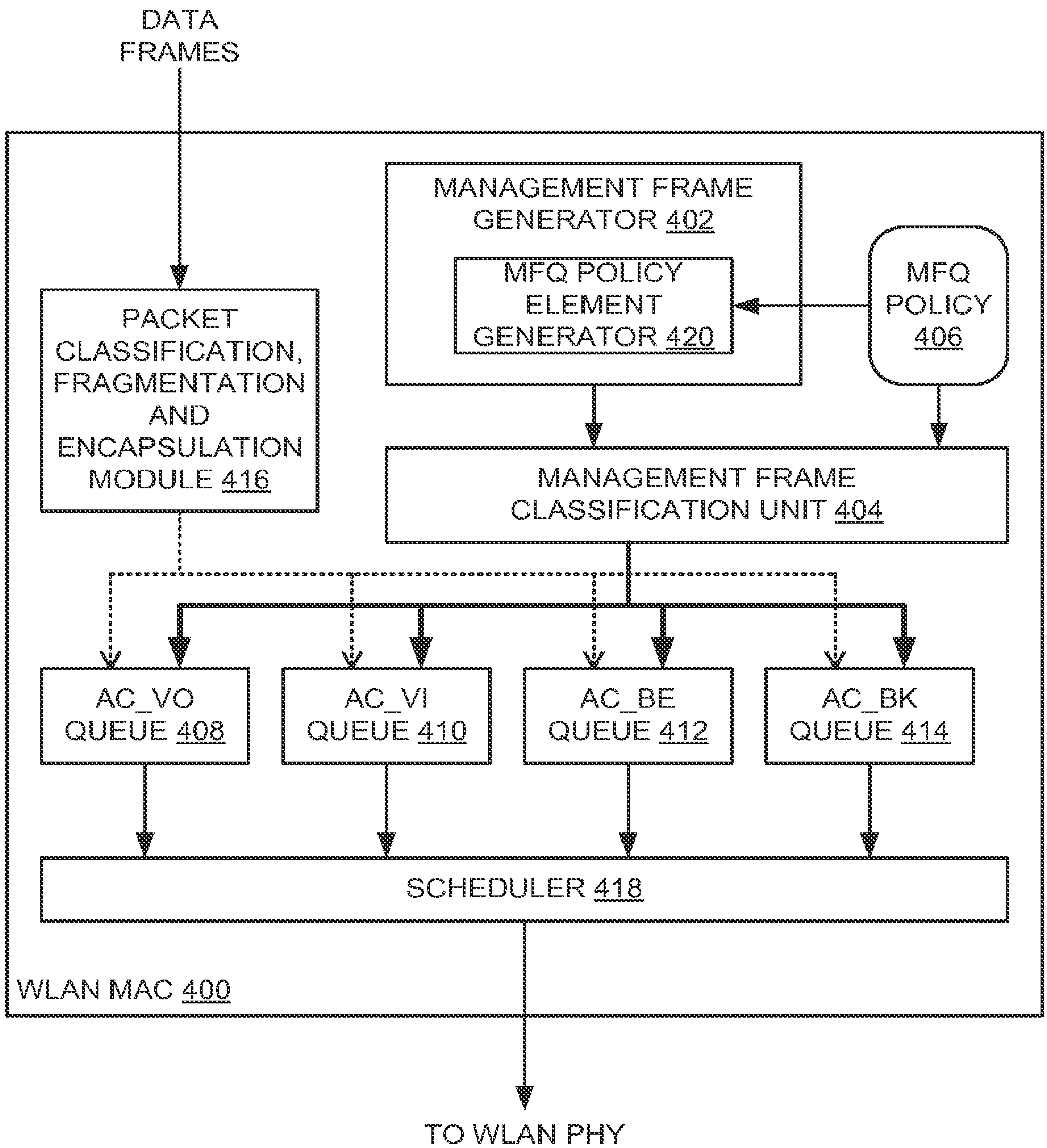

DATA FRAMES
MANAGEMENT FRAME GENERATOR 402
MFQ POLICY ELEMENT GENERATOR 420
MFQ POLICY 406
PACKET CLASSIFICATION, FRAGMENTATION AND ENCAPSULATION MODULE 416
MANAGEMENT FRAME CLASSIFICATION UNIT 404
AC_VO QUEUE 408
AC_VI QUEUE 410
AC_BE QUEUE 412
AC_BK QUEUE 414
SCHEDULER 418
WLAN MAC 400
TO WLAN PHY

FIG. 14

NEGOTIATION OF QUALITY OF SERVICE (QOS) INFORMATION FOR NETWORK MANAGEMENT TRAFFIC IN A WIRELESS LOCAL AREA NETWORK (WLAN)

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 17/146,189 filed Jan. 11, 2021 by Michael Peter Montemurro, et al. entitled, "Negotiation of Quality of Service (QoS) Information for Network Management Traffic in a Wireless Local Area Network (WLAN)", which is a continuation of U.S. patent application Ser. No. 16/428,350 filed May 31, 2019 by Michael Peter Montemurro, et al. entitled, "Negotiation of Quality of Service (QoS) Information for Network Management Traffic in a Wireless Local Area Network (WLAN)", which is a continuation of U.S. patent application Ser. No. 15/460,991 filed Mar. 16, 2017 by Michael Peter Montemurro, et al. entitled, "Negotiation of Quality of Service (QoS) Information for Network Management Traffic in a Wireless Local Area Network (WLAN)", which is a continuation of U.S. Pat. No. 9,615,383 issued Apr. 4, 2017 entitled, "Negotiation of Quality of Service (QoS) Information for Network Management Traffic in a Wireless Local Area Network (WLAN)", which claims priority to Canadian Patent Application No. 2,696,037 filed Mar. 15, 2010 entitled "Advertisement and Dynamic Configuration of WLAN Prioritization States", all of which are incorporated by reference herein as if reproduced in their entireties.

TECHNICAL FIELD

The technology described herein generally relates to wireless local area networks (WLANs), and more particularly, to the handling of network management traffic in a WLAN.

BACKGROUND

The enhanced Distributed Channel Access (EDCA) of the Institute of Electrical and Electronics Engineers (IEEE) standard 802.11 is an enhancement to the original IEEE 802.11 Media Access Control (MAC) sublayer and is a method of medium access described in the standard amendment document IEEE 802.11e. EDCA provides four prioritized queues for transmission, where each queue is associated with a different access category (AC). The four access categories defined, for example, in IEEE standard 802.11e, in decreasing priority, are AC_VO, AC_VI, AC_BE and AC_BK, named for voice traffic, video traffic, best-effort traffic, and background traffic, respectively. The queues use a contention-based mechanism to determine the next frame for transmission. The queue parameters are set such that the high priority queues have a preference for access to the wireless medium.

Management frames are the foundation of network management traffic in a Wireless Local Area Network (WLAN). Current IEEE 802.11 standards dictate that, in any access point (AP) or non-AP station (STA), management frames are to be handled via the EDCA queue of highest priority.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustration of an example network architecture for advertisement of management frame QoS (MFQ) information within a basic service set (BSS);

FIG. **2** is an illustration of an example method to be implemented by an access point (AP) for advertisement of MFQ information;

FIG. **3** is an illustration of an example method to be implemented by an AP for including MFQ information in a downlink frame;

FIG. **4** is an illustration of an example method to be implemented by a station (STA) associated with an AP for handling MFQ information received from the AP in a downlink frame;

FIG. **5** is an illustration of example formatting information for a MFQ element;

FIG. **6** is an illustration of an example method to be performed by a STA associated with an AP for requesting permission from the AP to deviate from MFQ information currently advertised by the AP, receiving a policy configuration response from the AP, and acting on the received policy configuration response;

FIG. **7** is an illustration of an example method to be performed by an AP for receiving a policy configuration request from an associated STA for permission to deviate from MFQ information currently advertised by the AP and for responding to the policy configuration request;

FIG. **8** is an illustration of example formatting for a policy configuration request;

FIG. **9** is an illustration of example formatting for a policy configuration response;

FIG. **10** is an illustration of example formatting for a policy stop message;

FIG. **11** is a block diagram of an example AP;

FIG. **12** is a block diagram of a example STA;

FIG. **13** is a block diagram of a media access control (MAC) sublayer module of an AP; and

FIG. **14** is a block diagram of a MAC sublayer module of a STA.

DETAILED DESCRIPTION

The disclosure can be better understood with reference to the following drawings and description. The components in the figures are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the disclosed technology. Moreover, in the figures, like referenced numerals designate corresponding parts or elements throughout the different views. The following description is merely exemplary in nature and is in no way intended to limit the disclosure, its application, or uses. As used herein, the term "module" refers to an Application Specific Integrated Circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that executes one or more software or firmware programs stored in the memory, a combinational logical circuit, and/or other suitable components that provide the described functionality. Herein, the phrase "coupled with" is defined to mean directly connected to or indirectly connected through one or more intermediate components. Such intermediate components may include both hardware and software based components.

Recent amendments to the IEEE 802.11 family of standards have increased the number and type of management frames, resulting in an increase in network management traffic. If all management frames continue to be handled as frames of the highest priority, this may adversely affect overall network performance or the ability to provide Quality of Service (QoS) to data frames or both. For example, it would not be desirable for the transmission of diagnostic reports to reduce the quality of a voice call.

By way of introduction, the disclosure is related to the prioritization of management frames and are merely exemplary in nature. More particularly, the present disclosure describes the implementation of prioritization scheme(s) that define various access categories of different management frames, where each of the access categories is associated with a respective prioritization used for transmission. An access category may be defined for a group of management frame subtypes or for an individual management frame subtype.

In the present disclosure, access categories AC_BK, AC_BE, AC_VI and AC_VO named for background traffic, best-effort traffic, video traffic, and voice traffic, respectively, are used to illustrate the concepts described herein. However, it is contemplated that the list of access categories may be different. If the list of access categories is different, then the number or definition or both of access-category-dependent queues in a compatible media access control (MAC) sublayer will also be different. An access category is a label given to a common set of enhanced distributed channel access (EDCA) parameters that are used, for example, by a station to contend for a channel in order to transmit information with certain priorities. In other words, each respective access category (e.g., AC_BK, AC_BE, AC_VI and AC_VO) is associated with (i.e., characterized by or indicative of) a respective priority used for transmission by a station.

Each data frame generated by an application in a non-access point (non-AP) station (STA) already has an indication of its priority. As used herein, the term “data frame” includes both a content data frame and a signaling data frame. For example, any one or any combination of the following values is an example indication of the priority of a data frame: a user priority assigned to the data frame; the IP-ToS (Internet Protocol-Type of Service) value in an IP header of the data frame; and a Differentiated Services Code Point (DSCP) value in the IP header of the data frame. The classification of a data frame to an access category by a MAC sublayer module of a non-AP STA may be based upon the data frame’s indication of priority. For example, data frames having various user priorities may be classified as follows:

User Priority	Access Category
001	AC_BK
010	AC_BK
000	AC_BE
011	AC_BE
100	AC_VI
101	AC_VI
110	AC_VO
111	AC_VO

Conventionally, management frames, in contrast to data frames, do not have an indication of priority, so there is no inherent classification of a management frame to an access category. Management frames are generated within the MAC sublayer module of an AP and/or a STA.

As proposed in the present disclosure, the prioritization scheme includes a default management frame QoS (MFQ) policy, which is a static definition of access categories for management frames. The default MFQ policy is implementable by a MAC sublayer module of an AP or non-AP STA. The default MFQ policy is known to all APs and STAs and is therefore not advertised. An example default MFQ policy includes the following definitions, where the access category of management frames not included in the following table is AC_BE:

Management Frame Subtypes	Access Category
Beacon	AC_VO
(Re)Association Request/Response	
Probe Request (individually addressed)	
Probe Response	
Announcement Traffic Indication Message (ATIM)	
Dissassociation	
Authentication	
Deauthentication	
Spectrum management - channel switch announcement	
QoS	
Block Ack	
Public - extended channel switch announcement	
Public - measurement pilot	
Public - TDLS Discovery Response	
Fast BSS Transition	
HT	
SA Query	
Protected Dual of Public Action - extended channel switch announcement	
Mesh Action - HWMP Mesh Path Selection	AC_VI
Self Protected	
Spectrum Management	AC_BE
Public	
Protected Dual of Public Action	
WNM	
Unprotected WNM	
Mesh Action	
Multihop Action	
Vendor-specific Protected	
Vendor-specific	

As proposed in the present disclosure, a MFQ policy will apply to a basic service set (BSS), which comprises an AP and any non-AP STAs associated with the AP. Therefore, the MFQ policy in effect in one BSS may differ from the MFQ policy in effect in a different BSS. In particular, the MFQ policy in effect in a BSS may differ from the default MFQ policy. The MFQ policies in effect in different BSSs belonging to the same extended service set (ESS) may be identical to one another, but this is not necessary. The MFQ policy in effect in a BSS may change over time. The prioritization scheme for management frames of the present disclosure is therefore dynamic in that the prioritization scheme allows for changes over time in the definition of access categories for management frame subtypes.

Furthermore, as proposed herein, the AP of the BSS will determine the MFQ policy that is currently in effect in the BSS and transmit management frames according that policy. The AP advertises MFQ information that describes how the MFQ policy currently in effect in the BSS differs from the default MFQ policy. Therefore, the MFQ policy currently in effect in a BSS may be referred to as the advertised MFQ policy, even though only the differences between the MFQ policy currently in effect in the BSS and the default MFQ policy are advertised. An associated STA is therefore informed of the MFQ policy currently in effect in the BSS through receipt of the advertised MFQ information.

In accordance with the present disclosure, an associated STA may follow the MFQ policy determined by the AP with which the STA is associated. Alternatively, an associated STA may follow the MFQ policy determined by the AP with which the STA is associated unless the STA has successfully negotiated a different MFQ policy with the AP. Compliance of an associated STA to the advertised MFQ policy or to the negotiated MFQ policy is not actually checked by the AP with which the STA is associated, because prioritization of management frames is handled internally in the STA prior to transmission of the frames.

Advertisement of MFQ Policy by AP

FIG. **1** is an illustration of an example network architecture for advertisement of MFQ information by an AP of a wireless local area network (WLAN). The WLAN may be configured using IEEE 802.11 technology, and/or or other wireless communication standards including other WLAN standards, personal area network (PAN) standards, wide area network (WAN) standards, or cellular communication standards or networks for providing wireless network communications.

In the network architecture shown in FIG. **1**, a WLAN access point (AP) **10** is coupled to a network **12**, possibly through a wired communication interface, a satellite interface, a Worldwide Interoperability for Microwave Access (WiMAX®) communication interface, or any other suitable communication interface. AP **10** broadcasts beacon frames. Stations **14** are WLAN devices that are within range (i.e., within communication range) of AP **10** and are associated with AP **10**. AP **10** and stations **14** together form a basic service set (BSS) **16**. A basic service set identifier (BSSID) identifies BSS **16**, and is included in every management frame sent by AP **10** or STAs **14**. The MAC address of AP **10** is often used as the BSSID. The network to which BSS **16** belongs is identified by its network name, referred to as a service set identifier (SSID). Unless hidden, the SSID is included in certain downlink frames, including, for example, beacon frames and probe response frames transmitted by AP **10**.

A station (STA) **18** is within range of AP **10** but is not associated with AP **10**. STA **18** is therefore not part of the BSS. STA **18** may detect the existence of AP **10** by undergoing a network discovery process to identify the available wireless local area networks within range. In some implementations, the network discovery process includes the receipt by STA **18** of beacon frames broadcasted by AP **10**. In some implementations, the network discovery process includes the transmission by STA **18** of a probe request frame and receipt by STA **18** of a probe response frame from AP **10** in response to the probe request frame.

A server **20** is coupled to AP **10** through network **12**. In the present implementation, server **20** is local to AP **10**. Alternatively, server **20** may be remote to AP **10**, and the coupling of server **20** to AP **10** may occur via other networks in addition to network **12**. For example, if server **20** is remote to AP **10**, the coupling of server **20** to AP **10** may occur via the Internet.

As explained in further detail in this disclosure, AP **10** advertises MFQ information that describes how the current MFQ policy in effect in BSS **16** differs from the default MFQ policy, and this advertisement may be received and interpreted by associated STAs, such as STAs **14**, and by non-associated STAs, such as STA **18**. Upon receipt of the advertised MFQ policy, a classification of management frames of the associated STA may be adjusted in accordance with the advertised MFQ policy. A non-associated STA, such as STA **18**, may use Access Network Query Protocol (ANQP) to query an AP, such as AP **10**, for the advertised MFQ policy. For example, a non-associated STA that is actively scanning may issue a probe request or a Generic Advertisement Service (GAS) request on an AP's channel in order to determine what MFQ policy the AP is implementing. However, such a non-associated STA may choose not to follow that MFQ policy. It should be noted that AP **10** transmits management frames according the current MFQ policy in effect (i.e., being implemented) within BSS **16**.

FIG. **2** illustrates an example method to be implemented by an AP for advertisement of MFQ information. At **22**, the AP creates an advertisement of MFQ information that describes how the current MFQ policy in effect in the BSS differs from the default MFQ policy. At **24**, the AP advertises the advertisement, thus advertising the current MFQ policy in effect in the BSS (i.e., the current MFQ policy). For the sake of simplicity and brevity, the present disclosure discusses one format of the advertisement generated by the AP though those skilled in the art will appreciate that other forms of the advertisement are anticipated.

In the example method illustrated in FIG. **3**, the advertisement is in the form of a MFQ policy element. The MFQ policy element defines access categories of management frames and, as mentioned above, is used to advertise and exchange MFQ policy between a STA and an AP. The AP generates a MFQ policy element at **26**. At **28**, the AP includes the MFQ policy element in downlink frames, for example, in beacon frames or in probe response frames or in both. As part of the process of generating a beacon frame and as part of the process of generating a probe response frame, the AP may regenerate the MFQ policy element to reflect the current MFQ policy in effect in the BSS. The MFQ policy element is not reused from an earlier beacon frame or probe response frame. Rather, the MFQ policy element is generated as part of the process of generating the beacon frame or probe response frame in which the MFQ policy element is to be included.

An AP may indicate support for management frame prioritization by setting an appropriate bit, referred to herein as MFQActivated, in the Capabilities field of the Extended Capabilities information element (IE) to a value of 1 or may indicate lack of support for management frame prioritization by setting that bit to a value of 0. One of the currently reserved bits of the Capabilities field of the Extended Capabilities IE (as defined in IEEE Std 802.11-2007) may be used for this purpose. Alternatively, presence of the MFQ policy element in the downlink frame may be an indication to STAs receiving the downlink frame that MFQ is enabled, and lack of presence of the MFQ policy element in the downlink frame may be an indication to STAs receiving the downlink frame that either the AP sending the downlink frame does not support MFQ, or the AP sending the downlink frame supports MFQ and there is no change to the current MFQ policy for the AP to advertise.

When the AP changes its current MFQ policy in effect in the BSS, the change is communicated in all the beacon frames transmitted during the Delivery Traffic Indication Message (DTIM) interval following the MFQ policy change. The change may be indicated, for example, by setting a change bit to a value of 1. The change bit may be part of the MFQ policy element or may be in another part of the beacon frame. Setting the change bit to 1 in all beacon frames transmitted during the DTIM interval following the MFQ policy change will ensure that most, if not all, STAs in the BSS will be informed of a change in MFQ policy for the BSS. For example, even if a STA is in an awake state only for beacon frames that includes DTIMs and is not awake to receive other beacon frames, that STA will still be informed of the change in MFQ policy, and therefore be prompted to check the MFQ policy element in the beacon frame. However, a STA that has set its ReceiveDTIMs parameter to "No" may not receive a beacon frame that informs of a change in MFQ policy for the BSS.

FIG. 4 illustrates an example method to be implemented by a STA associated with an AP for handling MFQ information received from the AP in a downlink frame. At **30**, the STA receives a downlink frame that includes a MFQ policy element. At **32**, the STA configures itself to implement the advertised MFQ policy. In other words, the STA configures itself to implement the default MFQ policy modified by the content of the MFQ policy element. As such, the STA assigns an access category to each management frame according to an access category assignment indicated in the MFQ policy element (i.e., the advertised MFQ policy).

FIG. **5** illustrates example formatting information for a MFQ policy element. In order that the advertisement may be received by associated STAs and by non-associated STAs, the size of the MFQ policy element complies with any upper limit on the size of an element in non-associated mode. In one implementation, an Element ID field **34** which is 1 octet in length includes a value indicating that the element is a MFQ policy element. A length field **36** which is also 1 octet in length stores the length of the MFQ policy element. The length of the MFQ policy element may vary, because information for multiple deviations from the default MFQ policy may be included in the MFQ policy element. A MFQ policy info field **38**, alternatively named "Access Category Assignment Count" field **38**, is 1 octet in length and includes a value indicating the number of deviations which are included in the MFQ policy element. MFQ policy info field **38** may also include a change bit to indicate whether the MFQ policy has changed. The "Deviation from default MFQ policy for management frame subtype #1" field **40**, alternatively named "Management Prioritization Policy for Category #1" field **40**, "Access Category Assignment #1" field **40**, or "Access Category Mapping #1" field **40**, stores a first deviation to be included in the advertised MFQ policy. Optionally, additional deviations may be provided in fields **42** and **44**. Fields **40**, **42** and **44** are all of variable length.

Any one or any combination of the following factors may be taken into account when determining a change to a MFQ policy: detection of changes in network conditions, anticipation of changes in network conditions, detection of changes in network loading (at the BSS level or at the ESS level or both), anticipation of changes in network loading (at the BSS level or at the ESS level or both), detection of changes in AP loading, anticipation of changes in AP loading, the presence or lack of a multi-media stream, detection of changes in a multi-media stream, anticipation of changes in a multi-media stream, and other operating conditions.

Negotiated MFQ Policy

An associated non-AP STA may negotiate with the AP with which it is associated in order to deviate from the advertised MFQ policy (i.e., the configured MFQ policy). FIG. **6** illustrates an example method to be performed by a STA associated with an AP for requesting permission from the AP to deviate from the advertised MFQ policy, receiving a response from the AP, and acting on the received response.

The method begins at **46** with a STA implementing the MFQ policy configured in its MAC sublayer module. At **48**, the STA transmits a policy configuration request, also referred to herein as an "MFQ Policy Config Request", to the AP to request a change in the MFQ policy used to transmit management frames between the STA and the AP (i.e., the responding AP). In other words, a MFQ Policy Config Request is used to negotiate a change or modification to the MFQ policy between a STA and an AP with which the STA is associated. The MFQ Policy Config Request transmitted by the STA includes or indicates a change(s) to the MFQ policy being implemented. The policy configuration request may be transmitted in response to a triggering event, for example, a network problem, application-related diagnostics, or a financial transaction. At **50**, the STA receives a policy configuration response from the AP.

The policy configuration request (i.e., the MFQ Policy Config Request) includes a MFQ policy element describing how a requested MFQ policy differs from the default MFQ policy. In other words, the MFQ policy element indicates a proposed change with reference to the default MFQ policy. Any one or any combination of the following factors may taken into account when determining a requested MFQ policy: detection of changes in the associated non-AP STA due to diminishing battery power levels, anticipation of changes in the associated non-AP STA due to diminishing battery power levels, detection that a current predicted motion of the non-AP STA will shortly take the non-AP STA out of radio coverage, so the requested MFQ policy prioritizes signaling frames over a poor link.

If, as shown at **52**, a policy configuration response, also referred to as a "MFQ Policy Config Response", from the AP indicates that a policy configuration request has been rejected by the AP (i.e., the proposed change(s) in the MFQ Policy Config Request has (have) been rejected), the STA that transmitted the request may continue at **46** to transmit management frames in accordance with the MFQ policy configured in its MAC sublayer module.

In this document, a "negotiated MFQ policy" is a requested MFQ policy requested in a policy configuration request that has been accepted by the AP. If, as shown at **54**, a policy configuration response received from the AP indicates that a policy configuration request has been accepted by the AP (i.e., the proposed change(s) in the MFQ Policy Config Request has (have) been accepted), the STA proceeds at **56** to implement the negotiated MFQ policy by configuring its MAC sublayer module to implement the default MFQ policy modified by the content of the policy element (i.e., the proposed changes) in the policy configuration request that has been accepted. In some implementations, both the STA and the AP may transmit management frames to each other in accordance with the changes to the MFQ policy that were indicated in the MFQ Policy Config Request. The negotiated MFQ policy applies only to the associated STA that made the policy configuration request and does not apply to any other STA in the BSS.

At some point following acceptance of a policy configuration request, the AP may send a policy stop message to the STA that made the policy configuration request. Alternatively, the STA that made the policy configuration request may send a policy stop message to the AP. As long as no policy stop message has been transmitted by the AP to the STA or by the STA to the AP, the STA may continue to implement the negotiated MFQ policy. However, if the STA determines at **58** that a policy stop message has been received from the AP or transmitted by the STA, the STA may at **60** configure its MAC sublayer module according to the MFQ policy currently advertised by the AP. The AP may have changed its advertised MFQ policy during the time that the STA was configured according to the negotiated MFQ policy. After the STA has at **58** received a policy stop message from the AP or transmitted a policy stop message to the AP, the STA may wait for an advertisement of the MFQ policy currently in effect for the BSS in order to configure its MAC sublayer module in accordance with the current advertised MFQ policy.

Optionally, a policy configuration response received from the AP may indicate that the STA should retry its policy configuration request, as shown at **62**. In this case, the policy configuration response may include a suggested MFQ policy (not shown) that the AP might accept upon request. At **64**, the STA may transmit another policy configuration request to the AP. This policy configuration request may be the same policy configuration request that was transmitted by the STA at **48**, or this policy configuration request may include a MFQ policy element received from the AP describing a suggested MFQ policy (not shown) suggested by the AP, or this policy configuration request may include a different MFQ policy element describing a different MFQ policy than the previously requested MFQ policy. After transmitting the other policy configuration request to the AP at **64**, the STA receives a new policy configuration response from the AP at **50**.

As an alternative to use of the policy stop message, a STA that no longer wishes to follow the negotiated MFQ policy may send to its associated AP a policy configuration request that includes an MFQ policy element identical to the MFQ policy element advertised by the associated AP. It is expected that the AP will accept a policy configuration request that is requesting the MFQ policy currently implemented in the BSS.

As an alternative to use of the policy stop message, an AP that wants a STA to stop following a negotiated MFQ policy may send to the STA a policy configuration request that includes an MFQ policy element identical to the MFQ policy element advertised by the associated AP. It is expected that the STA will interpret the policy configuration request as a command from the associated AP to stop following the negotiated MFQ policy and to begin following the advertised MFQ policy.

FIG. **7** illustrates an example method to be performed by an AP for receiving a policy configuration request from an associated STA for permission to deviate from a MFQ policy currently advertised by the AP and for responding to the request.

The method begins at **66** when the AP receives a policy configuration request from an associated STA. At **68**, the AP determines the result of the policy configuration request and includes the result in a policy configuration response to be transmitted to the STA. For example, the AP may determine to accept the policy configuration request or to reject the policy configuration request. Alternatively, the AP may determine that the STA should retry the policy configuration request. In the case that the AP determines that the result of the policy configuration request is retry, the AP may optionally determine at **69** a suggested MFQ policy to include in its policy configuration response to the STA. It is contemplated that such a suggested MFQ policy may be more likely to be accepted by the AP than the requested MFQ policy in the policy configuration request received from the STA at **66**.

Following the AP's determination of the result of the policy configuration request at **66** and its optional determination (if the result is retry) of a suggested MFQ policy to describe in a policy configuration response at **68**, the AP transmits the policy configuration response to the STA at **70**.

FIG. **8** illustrates example formatting information for a policy configuration request. A policy configuration request may be implemented as a particular type of management frame called an action frame. A Category field **72** which is 1 octet in length is set to a value for public action. A Public Action field **73** which is 1 octet in length is set to indicate a policy configuration request frame. A dialog token field **74** which is 1 octet in length is set by the STA to a value to enable the STA to keep track of its policy configuration requests. A MFQ policy element **76** field describes the particular MFQ policy that is being requested.

FIG. **9** illustrates example formatting information for a policy configuration response. A policy configuration response may be implemented as an action frame. Category field **72** is as described above for a policy configuration request. A Public Action field **78** which is 1 octet in length is set to indicate a policy configuration response frame. Dialog token field **74** is as described above for a policy configuration request and has the same value that was used to identify the policy configuration request for which this is a response. A Result Code field **80**, alternatively named "Status Code" field **80**, includes an indication that the AP accepts or rejects the policy configuration request to which the Dialog Token applies or that the STA should retry a request for a policy. An optional MFQ policy element field **82**, applicable when the content of the Result Code field **80** comprises an indication that the STA should retry a request, describes how a suggested MFQ policy differs from the default MFQ policy. The STA may request the suggested MFQ policy in place of the originally requested MFQ policy.

FIG. **10** illustrates example formatting information for a policy stop message. A policy stop message may be implemented as an action frame. Category field **72** is as described above for a policy configuration request. A Public Action field **84** which is 1 octet in length is set to indicate a policy stop message. Dialog token field **74** is as described above for a policy configuration request and has the same value that was used to identify the policy configuration request for which this is a policy stop message.

Implementation of MFQ Policy (Default, Advertised or Negotiated)

An AP or non-AP STA may configure its MAC sublayer module to implement an MFQ policy. The MFQ policy being implemented by the MAC sublayer module may be the default MFQ policy. Alternatively, the MFQ policy being implemented by the MAC sublayer module may be the default MFQ modified by an advertised MFQ policy element. Alternatively, the MFQ policy being implemented by the MAC sublayer module may be the default MFQ policy modified by a MFQ policy element in a policy configuration request that has been accepted. While a management frame is generated within the MAC sublayer module, the management frame will be assigned to an access category as defined by the MFQ policy, and subsequently transmitted, using the respective access category. In the present implementation, the management frame is directed, based on its assigned access category, to one of four EDCA prioritized queues where each of the prioritized queues is associated with a respective access category. As such, in the present implementation, a management frame assigned to AC_VO will be transmitted using a prioritization (i.e., a transmission priority) associated with AC_VO, a management frame assigned to AC_VI will be transmitted using a prioritization associated with AC_VI, a management frame assigned to AC_BE will be transmitted using a prioritization associated with AC_BE, and a management frame assigned to AC_BK will be transmitted using a prioritization associated with AC_BK. In other words, each access category (e.g., AC_VO, AC_VI, AC_BE and AC_BK) is indicative of a distinct prioritization (i.e., transmission priority) used to transmit a particular type or subtype of management frame. Handling of the contents of the prioritized queues may follow IEEE 802.11 scheduling and transmission rules. For example, a frame scheduler schedules frames from the prioritized queues to be passed to the physical (PHY) sublayer module for transmission over a channel of a wireless medium.

FIG. **11** is a block diagram of an example AP **100**. AP **10** is an example of AP **100**. AP **100** comprises a processor **102** coupled to a memory **104** and to a communication interface **106**. Communication interface **106** may be a wired communication interface, a satellite interface, a Worldwide Interoperability for Microwave Access (WiMAX®) communication interface, or any other suitable communication interface. AP **100** also comprises a WLAN interface **108** within a protocol stack **110** that is coupled to processor **102**. WLAN interface **108** comprises a logical link control (LLC) sublayer module **112**, a MAC sublayer module **114** and a PHY sublayer module **116**. The BSSID of AP **100** is stored in WLAN interface **108**, possibly in a register **18**. The SSID of the WLAN supported by AP **100** is stored in WLAN interface **108**, possibly in a register **120**. MAC sublayer module **114** may be compatible with IEEE 802.11. AP **100** also comprises an antenna **122** coupled to PHY sublayer module **116**. Protocol stack **110** may comprise higher layers **124**. ANQP support may be implemented in MAC sublayer module **114**.

Memory **104** may store an operating system **126** to be executed by processor **102**. Memory **104** may store applications **128** installed in AP **100** to be executed by processor **102**. Examples of applications **128** include a configuration application that enables a WLAN administrator to configure parameters of the WLAN, for example, its SSID and BSSID(s). Memory **104** may store code **130** which, when executed by processor **102**, results in one or more of the methods illustrated in FIGS. **2**, **3**, and **7**.

A default MFQ policy **132** is not advertised in the BSS. Depending upon implementation, default MFQ policy **132** may be stored in WLAN interface **108** (as illustrated) or in memory **104**. Depending upon implementation, an advertised MFQ policy **133** currently implemented by WLAN MAC sublayer **114** may be stored in WLAN interface **108** (as illustrated) or in memory **104**. AP **100** is able to advertise how advertised MFQ policy **133** differs from default MFQ policy **132**. AP **100** may optionally store data **134** related to one or more policy configuration requests that have previously been received from one or more associated STAs and related to one or more policy configuration responses that have previously been transmitted to one or more associated STAs. Data **134** may be implemented, for example, as records in a table, where the records are maintained on a per-AID (association identifier) basis. Depending upon implementation, data **134** may be stored in WLAN interface **108** (as illustrated) or in memory **104**.

AP **100** may comprise other elements that, for clarity, are not illustrated in FIG. **11**. Similarly, AP **100** may comprise a subset of the elements illustrated in FIG. **11**.

FIG. **12** is a block diagram of an example STA, for example, any one of STAs **14**. An STA **200** comprises a processor **202** coupled to a memory **204** and optionally to one or more other wireless communication interfaces **206**. For example, wireless communication interfaces **206** may comprise a short-range wireless communication interface such as a wireless personal area network interface, possibly compatible with the Bluetooth Specification Version 4.0 published 30 Jun. 2010 or its official successors. In another example, wireless communication interfaces **206** may comprise a wireless wide area network (WWAN) interface such as for cellular communications. One or more antennas **208** may be coupled to respective ones of the wireless communication interfaces **206**. An antenna may be shared among more than one wireless interface.

STA **200** also comprises a WLAN interface **210** within a protocol stack **212** that is coupled to processor **202**. WLAN interface **210** comprises a LLC sublayer module **214**, a MAC sublayer module **216** and a PHY sublayer module **218**. MAC sublayer module **216** may be compatible with IEEE 802.11. STA **200** also comprises an antenna **220** coupled to PHY sublayer module **218**. Protocol stack **212** may comprise higher layers **222**.

Memory **204** may store an operating system **224** to be executed by processor **202**. Memory **204** may store applications **226** installed in STA **200** to be executed by processor **202**. For example, applications **226** may comprise a control application to act on MFQ policy elements received from an AP. In a further example, applications **226** may comprise a Voice over Internet Protocol (VoIP) application. In yet another example, applications **226** may comprise a telephony application. Memory **204** may also store data (not shown) used by operating system **224** and applications **226**.

Memory **204** may store one or more WLAN connection profiles **228**, each identifying a wireless local area network by its SSID, as known in the art.

Memory **204** may store code **230** which, when executed by processor **202**, results in one or more of the methods illustrated in FIGS. **4** and **6**. Receipt of a downlink frame and handling of MFQ information describing an advertised MFQ policy may be implemented in MAC sublayer module **216**. ANQP support may be implemented in MAC sublayer module **216**.

A default MFQ policy **232** is not advertised in the BSS. Depending upon implementation, default MFQ policy **232** may be stored in WLAN interface **210** (as illustrated) or in memory **204**. Depending upon implementation, a MFQ policy **233** currently implemented by WLAN MAC sublayer **216** may be stored in WLAN interface **210** (as illustrated) or in memory **204**. STA **200** may optionally store data **234** related to one or more policy configuration requests made by the STA and related to one or more policy configuration responses received by the STA. STA **200** may store an indication of its requested MFQ policy and then overwrite currently implemented MFQ policy **233** with the negotiated MFQ policy upon receiving acceptance of the policy configuration request.

Memory **204** may store an audio coder-decoder (codec) **238** or a video codec **240** or both. STA **200** may comprise an audio input element **242** and an audio output element **244**, both coupled to processor **202**. STA **200** may comprise a video input element **246** and a video output element **248**, both coupled to processor **202**.

STA **200** may comprise a Global Positioning System (GPS) module **250** coupled to processor **202**.

STA **200** may comprise one or more user input elements **252** coupled to processor **202**. Examples of user input elements include a keyboard, a keypad, a touchscreen, a joystick, a thumbwheel, a roller, a touchpad, a trackpad, a capacitive touch pad, an optical touch pad, and any other type of navigation actuator.

STA **200** may comprise one or more user output elements coupled to processor **202**, of which a display **254** is illustrated. In the event that display **254** is a touchscreen, it functions also as a user input element.

STA **200** may comprise one or more alert components **256** coupled to processor **202**, to be activated in order to alert a user, for example, by sounding a buzzer, playing a ringtone, emanating light, or vibrating.

STA **200** may include mechanical interfaces, such as a power connector jack, a data interface port such as a

Universal Serial Bus (USB) port, a headphone jack, and other mechanical interfaces that are not explicitly shown.

STA **200** comprises a power pack **258** that provides power to the other components of STA **200**.

STA **200** may comprise other elements that, for clarity, are not illustrated in FIG. **12**. Similarly, STA **200** may comprise a subset of the elements illustrated in FIG. **12**.

FIG. **13** is a block diagram of a MAC sublayer module **300** of an AP, for example, MAC sublayer module **114** of AP **100**. MAC sublayer module **300** uses a management frame generator **302** to generate management frames which are distributed to different memory queues by a management frame classification unit **304**. Distribution to the different memory queues is done according to a MFQ policy **306** currently implemented in the BSS to which the AP belongs. Management frames of the type or types for which MFQ policy **306** defines the access category AC_VO are routed by management frame classification unit **304** through memory queue **308**. Management frames of the type or types for which MFQ policy **306** defines the access category AC_VI are routed by management frame classification unit **304** through memory queue **310**. Management frames of the type or types for which MFQ policy **306** defines the access category AC_BE are routed by management frame classification unit **304** through memory queue **312**. Management frames of the type or types for which MFQ policy **306** defines the access category AC_BK are routed by management frame classification unit **304** through memory queue **314**. In some implementations, MFQ policy **306** defines an access category other than the AC_VO access category associated with the highest priority queue **308** for at least one management frame type.

Data frames (content frames and signaling frames) received at MAC sublayer module **300** from an LLC sublayer module (not shown) of the AP, for example, LLC sublayer module **112**, may be processed by a packet classification, fragmentation and encapsulation module **316** in MAC sublayer module **300** and then subsequently routed through the same memory queues as the management frames.

A scheduler **318** schedules frames from memory queues **308**, **310**, **312** and **314** to be passed to a PHY sublayer module of the AP, for example, PHY sublayer module **116**. For example, IEEE 802.11e has separate minimum and maximum values for each access category. Within each access category, a random number is generated that represents a wait time as multiplied by a “slot time”. In IEEE 802.11a/g, a slot time is 9 microseconds. Once the wireless medium is quiet or unoccupied, a countdown begins before transmission. Each count is 9 microseconds in real time. For AC_VO queue **308**, the countdown begins at a value between 31 and 127. For AC_VI queue **310**, the countdown begins at a value between 127 and 255. For AC_BE queue **312**, the countdown begins at a value between 255 and 511. For AC_BK queue **314**, the countdown begins at a value between 511 and 1023. If the countdown is interrupted, it is paused until the wireless medium is once again quiet, and is then resumed from the value at which it was paused. If the countdowns for different queues begin at the same time, traffic in a higher priority queue will gain access to the wireless medium ahead of traffic in a lower priority queue.

MAC sublayer module **300** further comprises a MFQ policy element generator **320** which generates a MFQ policy element based on MFQ policy **306**. As described previously, a MFQ policy element may be included in certain management frames generated by management frame generator **302** to advertise an advertised MFQ policy. For example, a MFQ policy element generated by MFQ policy element generator **320** may be included in a downlink frame such as a beacon frame or a probe response frame that is generated by management frame generator **302**. It should be noted that, while not explicitly shown, MAC sublayer module **300** may also implement ANQP support.

FIG. **14** is a block diagram of a MAC sublayer module **400** of a STA, for example, MAC sublayer module **216** of STA **200**. MAC sublayer module **400** uses a management frame generator **402** to generate management frames which are distributed to different memory queues by a management frame mapping unit **404**. Distribution to the different memory queues is done according to a MFQ policy **406**. Management frames of the type or types for which MFQ policy **406** defines the access category AC_VO are routed by management frame classification unit **404** through memory queue **408**. Management frames of the type or types for which MFQ policy **406** defines the access category AC_VI are routed by management frame classification unit **404** through memory queue **410**. Management frames of the type or types for which MFQ policy **406** defines the access category AC_BE are routed by management frame classification unit **404** through memory queue **412**. Management frames of the type or types for which MFQ policy **406** defines the access category AC_BK are routed by management frame classification unit **404** through memory queue **414**. In some implementations, MFQ policy **406** defines an access category other than the AC_VO access category associated with the highest priority queue **408** for at least one management frame type.

It is contemplated that MFQ policy **406** is an advertised MFQ policy. It is also contemplated that MFQ policy **406** is a negotiated MFQ policy accepted by an AP with which the STA is associated. It is also contemplated that MFQ policy **406** is the default MFQ policy.

Data frames (content frames and signaling frames) received at MAC sublayer module **400** from an LLC sublayer module (not shown) of the STA, for example, LLC sublayer module **214**, may be processed by a packet classification, fragmentation and encapsulation module **416** in MAC sublayer module **400** and then subsequently routed through the same memory queues as the management frames.

A scheduler **418** schedules frames from memory queues **408**, **410**, **412** and **414** to be passed to a PHY sublayer module of the STA, for example, PHY sublayer module **218**. For example, IEEE 802.11e has separate minimum and maximum values for each access category. Within each access category, a random number is generated that represents a wait time as multiplied by a “slot time”. In IEEE 802.11a/g, a slot time is 9 microseconds. Once the wireless medium is quiet or unoccupied, a countdown begins before transmission. Each count is 9 microseconds in real time. For AC_VO queue **408**, the countdown begins at a value between 31 and 127. For AC_VI queue **410**, the countdown begins at a value between 127 and 255. For AC_BE queue **412**, the countdown begins at a value between 255 and 511. For AC_BK queue **414**, the countdown begins at a value between 511 and 1023. If the countdown is interrupted, it is paused until the wireless medium is once again quiet, and is then resumed from the value at which it was paused. If the countdowns for different queues begin at the same time, traffic in a higher priority queue will gain access to the wireless medium ahead of traffic in a lower priority queue.

MAC sublayer module **400** further comprises a MFQ policy element generator **420** which generates a MFQ policy element based on a requested MFQ policy. As described previously, the MFQ policy element may be included in a policy configuration request generated by management frame generator **402** to negotiate a deviation from an advertised MFQ policy. It should be noted that, while not explicitly shown, MAC sublayer module **400** may also implement ANQP support.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

What is claimed:

1. A method for a mobile station, the method comprising:

receiving, from the access point, a management frame quality of service (MFQ) policy that defines an access category used for transmitting a first type of management frame; and

transmitting a policy configuration request to request a change to the MFQ policy,

wherein the policy configuration request indicates a number of differences between a requested MFQ policy and a default MFQ policy.

2. The method of claim **1**, wherein management frames are distinct from signaling frames and content frames.

3. The method of claim **1**, wherein the policy configuration request includes an MFQ policy element indicative of the requested change.

4. The method of claim **1**, further comprising receiving, from the access point, a policy configuration response in response to the policy configuration request.

5. The method of claim **4**, wherein the policy configuration response includes an indication that the change has been accepted by the access point.

6. A mobile station, comprising:

a processor; and

memory storing instructions executable by the processor such that when executed, cause the processor to:

receive, from the access point, a management frame quality of service (MFQ) policy that defines an access category used for transmitting a first type of management frame; and

transmit a policy configuration request to request a change to the MFQ policy, wherein the policy configuration request indicates a number of differences between a requested MFQ policy and a default MFQ policy.

7. The mobile station of claim **6**, wherein management frames are distinct from signaling frames and content frames.

8. The mobile station of claim **6**, wherein the policy configuration request includes an MFQ policy element indicative of the requested change.

9. The mobile station of claim **6**, wherein the processor is further configured to receive, from the access point, a policy configuration response in response to the policy configuration request.

10. The mobile station of claim **9**, wherein the policy configuration response includes an indication that the change has been accepted by the access point.

11. A method for an access point, the method comprising:

transmitting, to the mobile station, a management frame quality of service (MFQ) policy that defines an access category used for transmitting a first type of management frame; and

receiving a policy configuration request to request a change to the MFQ policy,

wherein the policy configuration request indicates a number of differences between a requested MFQ policy and a default MFQ policy.

12. The method of claim **11**, wherein management frames are distinct from signaling frames and content frames.

13. The method of claim **11**, wherein the policy configuration request includes an MFQ policy element indicative of the requested change.

14. The method of claim **11**, further comprising transmitting, to the mobile station, a policy configuration response in response to the policy configuration request.

15. The method of claim **14**, wherein the policy configuration response includes an indication that the change has been accepted by the access point.

16. An access point comprising:

a processor; and

memory storing instructions executable by the processor such that when executed, cause the processor to:

transmit, to the mobile station, a management frame quality of service (MFQ) policy that defines an access category used for transmitting a first type of management frame; and

receive, from the mobile station, a policy configuration request to request a change to the MFQ policy, wherein the policy configuration request indicates a number of differences between a requested MFQ policy and a default MFQ policy.

17. The access point of claim **16**, wherein management frames are distinct from signaling frames and content frames.

18. The access point of claim **16**, wherein the policy configuration request includes a MFQ policy element indicative of the requested change.

19. The access point of claim **16**, wherein the processor is further configured to transmit, to the mobile station, a policy configuration response to the mobile station in response to the policy configuration request.

20. The access point of claim **19**, wherein the policy configuration response includes an indication that the change has been accepted or rejected by the access point.

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